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WHENCE CAME MAIZE TO ASIA?

BY

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THE intriguing question of pre-Columbian trans-Pacific diffusion is with us again and modern Kon-Tikis now compete with ancient Alexandrian fleets in the alleged South Pacific Regatta. To the interested but confused onlooker, it might appear that the specialists are divided into two opposing camps with adventurous diffusionists in bitter conflict with obstinate and reactionary proponents of independent invention. To some of the individual specialists involved, the issue may, indeed, have this emotional coloring. Basically, however, the lines are drawn between those who are short on facts and use them uncritically (although sometimes with superb imagination) and those who demand evidence and valid reasoning. In the paper on maize in Assam, which is the principal basis for this critique, neither the authors' selection of facts nor their reasoning from those facts can, in our opinion, support their theory of a pre-Columbian diffusion of maize across the Pacific. In their favor, however, it must be added that they do not profess to know in which direction the diffusion took place.

The question as to which part of the world gave rise to maize is by no means new, since it is one upon which

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students of plants have differed for more than four centuries. Sturtevant, a careful student of maize and of the literature pertaining to it, compiled (1879) lists of names of prominent herbalists and early botanists who had expressed opinions on the geographical origin of maize. Among those who regarded maize as a plant of Old World origin were: Bock, Ruellius, Fuchs, Sismondi, Michaud, Gregory, Lonicer, Amoreux, Regnier, Viterbo, Donicer, Tabernaemontanus, Bonafous, St. John, de Turre, Daru, de Herbelot and Klippart. Equally impressive is the roster of those who believed maize to be an American plant: Dodoens, Camerarius, Matthioli, Gerard, Ray, Parmentier, Descourtilz, de Candolle, Humboldt, Darwin, F. Unger, Von Heer, de Jonnes, Targioni-Tozzetti, Hooker, Figuer, Nuttall, Mrs. Somerville and Flint. De Candolle's case (1855) for the American origin of maize was so convincing and the evidence which he marshalled to support his conclusions so substantial that the possibility of an Old World origin of maize has received little consideration from serious students in more recent times. Especially has this been true since Ascherson (1875) demonstrated the close relationship of maize and teosinte, a plant unmistakably American.

The question of a pre-Columbian distribution of maize in Asia has, however, been raised at least twice in this century, first in 1909 by Collins, and now by Stonor and Anderson (1949). The last named paper, since it purports to present new evidence on the question and coinciding as it does with a fashionable new preoccupation with the old problem of trans-Pacific diffusion of pre-Columbian cultures, has been of particular interest. We have been requested by a number of anthropologists to review it and to evaluate the evidence on which it is based. The paper has already been critically discussed by Merrill (1950), who has questioned its principal con-

clusions on general botanical and ethnological grounds, and by Weatherwax (1950), who has quite appropriately emphasized the important and fundamental differences which exist between maize and its Asiatic relatives, and has simultaneously emphasized the similarities among the American Maydeae. We propose here to examine critically the botanical and ethnographic evidence concerned with maize upon which the far-reaching conclusions of the authors rest.

Stonor and Anderson found the hill peoples of Assam growing a group of maize varieties with characters said to be "unusual" and utilizing them for food, feed, and brewing. This maize which the authors designate as "Race A" is said to be unknown in the coastal regions of Asia, but rather widely distributed in Central Asia; furthermore, it seems to resemble certain South American maize also designated as "Race A" which is common archaeologically and certain features of which are still to be found, although rarely, among living South American varieties. These peculiar Asiatic varieties differ profoundly from those of "Race C" which also occur in both Asia and America, but which in Asia are largely confined to the coastal regions. The introduction of Race C to Asia is admittedly post-Columbian.

These facts are regarded by the authors as "fantastic," and it is stated that "any satisfying hypothesis must border on the miraculous." They conclude that maize presumably "must either have originated in Asia or have been taken there in pre-Columbian times."

The evidence upon which these sweeping conclusions rests falls into three categories: (1) botanical evidence concerning the maize in question; (2) ethnographic evidence on the maize-using tribes and the uses to which maize is put; (3) supporting evidence from Polynesia in favor of trans-Pacific diffusion. We shall consider only

the first two categories, since the third has already been discussed by Merrill and will undoubtedly receive additional attention from others who are better qualified than we to evaluate it.

The Botanical Evidence

The botanical evidence may in turn also be considered under three categories: (a) that the Assamese maize is unique and is related only to archaeological maize in America; (b) that the present distribution of Races A and C can be explained only in terms of a pre-Columbian diffusion of one of them; (c) that Assamese maize resembles sorghum.

Five varieties of maize from Assam are described. The following "unusual" characters are said to typify one or more of these varieties.

1. Uniformly green leaves, culms, silks and anthers.
2. Slender pendent tassel branches.
3. Straw-yellow endosperm; dull bluish-red aleurone.
4. Small isodiametrical kernels.
5. Many short internodes; lack of vegetative vigor.
6. Upright twisted tassel branches; short silks.
7. Tassel partly enclosed in a spathe-like cluster of leaves.
8. A distinct bloom on the leaves and culm.[2]
9. Waxy pollen and endosperm.

These characteristics, although not common, are nevertheless well-known to those familiar with the great diversity of maize in Latin America. Separately most of them are widely distributed not only in South America, but also in Central America and Mexico. Even in com-

[2] This character was not specifically included in their list, but is mentioned separately as one of the characteristics of the variety *Late Sidewise*.

bination they are by no means unique. In this connection the following observations made largely on varieties of maize in the collections of the senior author are pertinent.

1. Uniform greenness resulting from a complete lack of anthocyanin coloration is indeed almost unknown, at least in pure form, in the indigenous maize varieties of Latin America. Virtually all maize, however, has at least a trace of anthocyanin color in the seedlings where it occurs in the coleoptile or leaf sheath, in the tip of the leaf blade, or along the leaf margins. Consequently, if the Assamese varieties are actually completely lacking in anthocyanin pigmentation, they are indeed almost unique. Unfortunately, the authors do not report specifically on anthocyanin color in the seedlings, stating only that: "The group as a whole had a strong tendency to green silks, green anthers, green leaves, and green culms." Plants of this general description are the product of two recessive alleles at the *B* and *Pl* loci on chromosomes 2 and 6 respectively and of one of the lower alleles at the *R* locus on chromosome 10. Such plants are not common, but occur regularly throughout Latin America. In 1950, we grew 513 collections of corn from sixteen Latin-American countries. Among these were 27 varieties which contained plants lacking in anthocyanin color in the leaves, culms, silks and anthers. These occurred in collections from Mexico, Guatemala, Honduras, Nicaragua, Colombia, Ecuador, Peru, Venezuela, Brazil, Uruguay and Paraguay. They had their highest frequency in the varieties of eastern South America. Of 40 varieties from Venezuela, Brazil, Paraguay and Uruguay which were studied in 1950, eight, or one variety in five, contained some uniformly green plants compared to one variety in 19 for the group as a whole. So far as anthocyanin coloration alone is concerned, the Assamese vari-

eties, therefore, have their affinities in the corn varieties of eastern South America.

In so far as uniform greenness has any bearing upon the origin of maize, it points to Asia, not as a center of origin, but as a peripheral region where recessive genes have become "emancipated" through the process of "genetic drift." The counterpart of this situation occurs in rice which in the United States is represented largely by uncolored (green) varieties, but which has colored varieties in the Old World (Jones, 1930). In rice, as in maize, at least three loci are involved in anthocyanin coloration.

2. Pendent tassels, like lack of anthocyanin color, although not common, are found in varieties from several countries, including Mexico, Guatemala, Honduras, Costa Rica, Nicaragua, Venezuela, Colombia, Peru and Ecuador. The combination of pendent tassels and all-green plants occurs in only seven of these nine countries, not having been found in Costa Rica and Honduras. All-green plants with strongly pendent tassels are most common in Colombia where many other of the "unusual" characters of the Assamese maize also occur.

3. Straw-colored endosperm is not at all unusual among non-Tripsacoid varieties. Dull bluish-red aleurone is the product of superimposing blue aleurone on waxy endosperm and is a characteristic quite familiar to the majority of practicing maize geneticists.

4. Small isodiametrical kernels are characteristic of many South American pop corns. Dr. Anderson kindly sent us kernels of several of the Assamese varieties. It was possible to match more than half of these in size, shape and color from a single collection of Colombian pop corns.

5. Lack of vegetative vigor, manifested especially by the slowness of the tassel to reach the pollen-shedding

stage after emergence has begun, is characteristic of many South American and some Mexican varieties. It is surely of little significance in the Assamese varieties which are obviously rather highly inbred, if the statements of the authors are correct regarding their uniformity and the fact that they are sometimes grown as single plants among other cereals. Lack of vigor is characteristic of many American inbred strains.

We have no data on internode pattern.

6. We have no observations on upright tassel branches and short silks.

7. The spathe-like cluster of leaves partly enclosing the tassel is not uncommon in Colombian varieties.

8. The grayish bloom which shows some resemblance to the bloom characteristic of sorghum (and many other grasses) occurs in our collection only on varieties from Colombia.

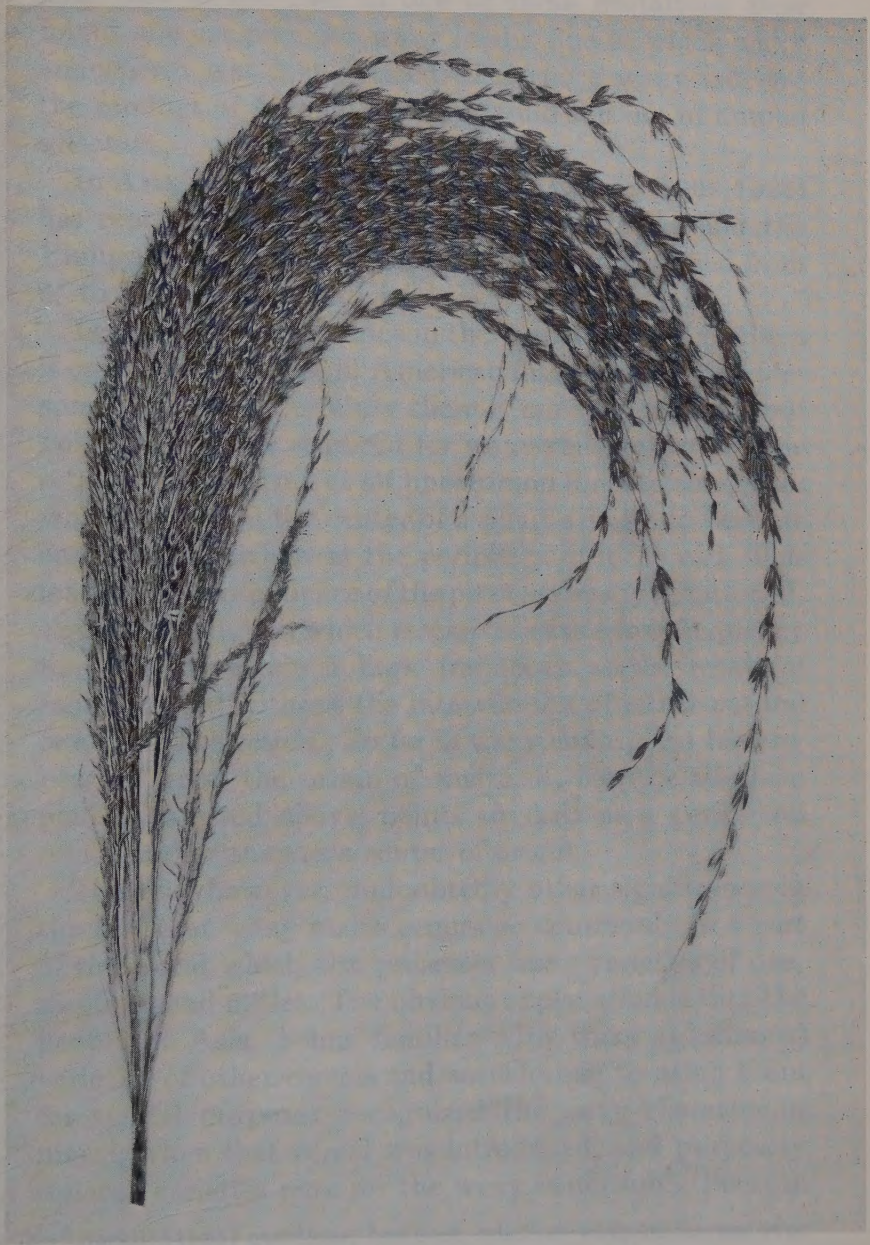
9. Perhaps the most important "unusual" characteristic of the Assamese maize is the waxy endosperm which occurs in several varieties. It was the discovery of this character in Chinese maize which led Collins (1909) to reopen the question of a pre-Columbian distribution of maize in Asia.

Waxy endosperm is a simple Mendelian character in maize which affects the chemical composition. The starch of waxy maize is composed exclusively of amylopectin, while that of non-waxy varieties contains both amylose and amylopectin. Waxy varieties of maize are unknown in pure form in America, but the waxy character itself has been discovered in non-waxy varieties: in a New England flint corn by Mangelsdorf (1924) and in a South American variety by Breggar (1928). Bear (1944) has found that waxy endosperm is not an uncommon mutant in Corn-Belt dent corn varieties. He found three separate mutations in three consecutive years in a total pop-

EXPLANATION OF THE ILLUSTRATION

PLATE XLVIII. A pendent tassel of one of the Colombian pop-corn varieties which resembles in several characteristics the Assamese race *Late Sidewise* described by Stonor and Anderson. Note, at lower left, the sterile spikelets resulting from the failure of the tassel to emerge completely from the spathe-like sheath. Note, at right, the lax central spike with spikelets borne in whorls at widely separated nodes. Note the solitary spikelets at the ends of several branches.

Plate XLVIII



ulation of some 100,000 selfed ears. It is of interest to note that in the case of one of these mutations Bear found one ear pure for waxy in the line in which waxy endosperm was first noticed. This pure waxy ear was the product of Mendelian segregation and not of human selection.

In Asia, waxy maize is widespread. Collins (1909, 1920) has reported its occurrence in China, Burma and the Philippines. Kuleshov (1928) states that it is spread from 5° to 45° north latitude in Asia.

Is there any significance in the fact that a gene which is comparatively rare in American maize should be widespread in Asia? Certainly there is none from the standpoint of the time required for waxy varieties to become established. It is not at all uncommon for recessive genes which are rare at the center of a plant's origin to become common somewhere at the periphery of its spread. This is a natural consequence of the process already mentioned, "genetic drift," in which recessives with a low frequency may rapidly attain a high frequency as the result of sampling and without the intervention of either natural or artificial selection. So far as waxy endosperm has any bearing upon the origin of maize, it, like the all-green plants discussed above, points to Asia as a peripheral region rather than as a center of origin.

There is, however, undoubtedly other significance in the fact that waxy maize occurs so commonly in a part of the world which also possesses waxy varieties of rice, sorghum and millet. The obvious explanation is that the people of Asia, being familiar with waxy (glutinous) varieties of other cereals and accustomed to using them for special purposes, recognized the waxy character in maize, when that cereal was introduced, and purposely isolated varieties pure for the waxy condition[3]. Because

[3] Burkill (1935) questions, however, whether waxy maize was ever

waxy endosperm is a recessive, this task would have been simple and well within the abilities of even the most primitive hill peoples. Indeed, the practice of growing maize as single plants among other cereals, reported by Stonor and Anderson, would promote self-pollination, and in any stock in which the waxy gene occurred would inevitably lead in a very short time to the establishment of pure waxy varieties whose special properties people accustomed to the waxy character in other cereals could hardly fail to recognize. Man's part in the establishment of waxy varieties of maize in Asia need have been no greater than a recognition of this type and a willingness to preserve it once it was presented to him as the product of random sampling.

But much more important than the individual characters of the Assamese maize is the fact that these characters occur as a "complex" in Asia: a complex which is said to be rare in South America and "nothing like it" to be known in Mexico, Guatemala or other parts of Central America. How accurate is this statement and how valid the conclusions regarding the uniqueness of Assamese maize?

The complex of characters in its entirety has not been reported from Mexico and Central America, but does (if we exclude waxy endosperm as an integral part of the complex) occur in South America. The authors themselves mention two varieties from Chile, one from Argentina, and several from Bolivia which have a number of features in common with the Assamese maize, and they quote Brieger as noting these characteristics in other parts of South America. The most unusual of the Assamese varieties, called *Late Sidewise*, which is said to look

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selected for its waxiness and suggests that it was preserved only because of the peculiar suitability of its sheaths for cheroots. This problem merits further study.

"unlike anything previously reported for *Zea Mays*" has strong affinities, if not exact counterparts, among the living varieties of Colombia. In 1949, we noted, in a group of pop-corn varieties sent from the Department of Caldas in Colombia by Dr. J. G. Hawkes, in a pop corn received from Dr. R. E. Schultes collected slightly north of Buenaventura, and in pop corn purchased by the senior author in the market in Bogotá, practically all of the characteristics mentioned in the description of *Late Sidewise*, including the bluish-green color of the leaves and the culms and the distinct bloom which lends to the plants a superficial resemblance to sorghum.

These Colombian pop corns are of unusual ethnographic and botanical interest. They are known locally as *maiz indio* and, according to Dr. Hawkes, they are grown by the Indians in a primitive way, the seed being sown broadcast and the crop receiving no weeding or cultivation from the time of planting until harvest. A similar statement about the method of sowing accompanied the collection made by Dr. Schultes. One of the ears (No. 1355) of the Colombian pop corn (inadvertently shelled off and put into cold storage before a photograph could be made) was almost a duplicate of the ear (Stonor No. 18) illustrated in Plate 21 of Stonor and Anderson. Of seven distinct samples of kernels of Assamese maize sent to the senior author by Dr. Anderson, five could be matched almost exactly in size, shape and color with Colombian pop corns. The pendent tassels of these corns are illustrated in Plate XLVIII. They are of further botanical interest because of the slender, lax central spikes of the tassel, on which the spikelets are borne in distinct whorls separated by conspicuous internodes. The tips of the tassel branches often bear solitary staminate spikelets. The plants tiller profusely and have numerous elongated lateral branches. It was noted in 1949 that: "these

plants look like corn-teosinte hybrids," but there is no other indication that they are the product of recent teosinte contamination.

The complex of characters described for the *Late Sidewise* maize of Assam is, as Stonor and Anderson concluded, an unusual one. It is, however, not unique nor confined to Asia. The fact that it occurs in Asia is not, in our opinion, evidence either that maize originated there or that it was taken there in pre-Columbian times. The maize of Italy is in some respects as unusual as the maize of Assam, but it, too, has American affinities. No maize has yet been found in any part of the Old World which does not have its counterparts in America. The maize of Assam is no exception to this general rule.

The authors make much of the fact that the predominating maize of Assam, Race A, is not represented in collections of the maize from the Asiatic coast, and they ask how such a race of maize could have gotten to a number of isolated hill areas in Asia without leaving a very definite record along the coast. "That maize," they state, "could in post-Columbian times have spread to each of these various hinterlands without entering into the economies of the more civilized people who would have handed it on almost passes belief." And again, "To believe that in post-Columbian times maize could have penetrated not only to the Naga but to the hill tribes of Upper Burma, and of Siam, to the Lolo in central Asia, to the aborigines of Hainan, to the hill peoples of Sikkim, and to the interior of New Guinea, in each case passing over the more civilized peoples along the coast is beyond credulity."

For us it is more difficult to believe that maize could have occurred in pre-Columbian times in all of these places, as well as in the coastal regions where it has now presumably disappeared; and perhaps throughout Cen-

tral Asia from Persia and Turkestan to Tibet and Siberia where it now occurs, without leaving a single prehistoric trace of any kind. Yet there is no tangible evidence of the existence of maize in Asia or any other part of the Old World before 1492. When we consider how thoroughly other economic plants were treated in the extensive ancient literature of Asia and the Near East, and how popular maize became as a cultivated plant and as a subject for artistic treatment after the discovery of America, it taxes our credulity to believe that all of the civilized people of the Old World could have remained ignorant of a food plant at once so widely distributed, so peculiar in its characteristics and so useful to mankind.

Burkill (1935), probably the leading authority on the economic plants of the Far East, came to a similar conclusion. He states: "The strongest reason against the belief [of a pre-Columbian distribution of maize in China] lies in the unanswerable argument that no plant of such value could have remained hidden in the Far East, if there."

Actually the absence of Race A in the coastal regions of Asia is not difficult to explain, if indeed it requires explanation. In the first place, its absence among the very limited collections so far made from the coastal regions of Asia is far from conclusive proof that it does not occur. But if we assume for the purpose of discussion that Race A actually is absent at low altitudes in Asia, then there are several possible explanations which do not require the assumption of pre-Columbian diffusion. An obvious one is that the more productive Tripsacoid varieties of the second race, Race C, have already, in coastal regions, largely replaced the non-vigorous unproductive varieties of Race A, earlier introduced, as they are perhaps in the process of doing in the hills where Race C now also occurs along with Race A. The counterpart of

this process can be observed in many parts of North and South America today.

A second possible answer, probably the correct one, was given, forty years before the question was raised, by Laufer who, as the result of his scholarly historical studies, concluded that maize came into China, not from across the Pacific, but overland through Tibet from India. This conclusion is quite in harmony with the facts of both history and geography. Colombia, for example, where living counterparts of the Assamese maize are now known to occur, is actually appreciably nearer to Assam via the Caribbean Sea, the Atlantic Ocean and Africa than via the Pacific. Furthermore, the first route, being more largely a land route, does not demand the fabulous feats of navigation on the part of pre-Columbian people which the second does.

This does not mean that Laufer's conclusions on the introduction of maize into Asia are necessarily completely correct and final. However, until new evidence in conflict with them is brought forward, they furnish a satisfactory explanation of the facts now at our command. This is recognized by Stonor and Anderson who state that accepting the morphological similarity of American and Asiatic maize as a premise, Laufer "could have come only to the conclusion he finally reached: that maize somehow got to Indian ports at an early post-Columbian date and spread overland via various primitive peoples to China." Since it can now be shown that the Assamese maize is indeed similar to American maize, the evidence presented by Stonor and Anderson tends to confirm rather than to contradict Laufer's conclusions.

In his part of their joint paper, Anderson emphasizes the resemblance of the Assamese maize in several characteristics to sorghum, the implication apparently being that this resemblance has some bearing upon the possi-

bility of an Old World origin of maize, since sorghum is undeniably an Old World cereal. Actually the alleged resemblances of Assamese maize to sorghum are either superficial or are examples of the well-known phenomenon of parallel variation which is especially well exemplified among plants by the cultivated cereals and among animals by the rodents.

In the category of superficial resemblances are the isodiametric straw-colored or dull blue kernels. Maize kernels when not crowded tend to be spherical, and the fact that kernels of Assamese maize approach this general shape merely indicates that they are borne on ears on which the kernels are not crowded. This is true of many varieties of South American maize. Furthermore, *any* variety of maize will produce spherical sorghum-like kernels when it bears kernels in the tassel, as practically all varieties are capable of doing when grown in small pots in the greenhouse or when otherwise stunted.

The resemblance in kernel color between the Assamese maize and sorghum is meaningless, since entirely different color-bearing tissues are involved in the two plants. The yellow and blue colors of the Assamese maize are endosperm and aleurone colors respectively and occur in triploid tissue resulting from the process of double fertilization which is characteristic of the Angiosperm seed. The colors of sorghum kernels occur in the pericarp and nucellar layer both of which are diploid maternal tissues (Swanson, 1928). So far as we know, endosperm and aleurone colors have never been reported in sorghum.

The resemblances of Assamese maize to sorghum in lacking anthocyanin pigmentation and in possessing a distinct bloom are nothing more than typical examples of parallel variations in cereals and other cultivated grasses such as sugar cane, in which variations in antho-

cyanin coloration and the presence or absence of bloom are the rule rather than the exception. To find the grayish bloom, one need go no further than corn's closest relative, teosinte.

Finally, to link the Assamese maize with the ancient Bat-Cave corn described by Mangelsdorf and Smith (1949) by comparing both to sorghum is scarcely justified. The Bat-Cave corn resembles sorghum in its small kernels, long glumes, and the fact that the upper glumes are as long or longer than the lower. These, however, are characteristics found in many varieties of pod corn.

To emphasize the resemblance of maize to sorghum or to any other of the Old World relatives of maize without also calling attention to the existence of profound and fundamental botanical differences is to present a misleading picture. Maize does, indeed, resemble sorghum in its general growth habit as well as in chromosome number, and it resembles its Asiatic relatives Coix, Schlerachne, Chionachne and Polytoca in being monoecious. It differs from all of these, however, either in the development of its florets or in the nature of its fruit case. Weatherwax, some years ago (1926), called attention to the superficiality of some of the resemblances between maize and its Oriental relatives. He states:

> In all the Maydeae the fruit is wholly or partly covered by an indurated shell, which is an especially attractive superficial indication of relationship. Its relative absence in Zea may be explained by the unusually complicated covering of husks, or as a result of conscious selection by man. But this general occurrence of a hard shell is a deceptive analogy, rather than a homology. The indurated structure is a combination of a glume and an alveolus of the rachis in Tripsacum and Euchlaena [as well as in Zea], a spathe in Coix, and a glume in Polytoca, Schlerachne and Chionachne. A tendency toward induration of something connected with the fruit seems, therefore, to be all that the genera have in common, and this is possessed by so many other genera of grasses as to be of little significance in determining tribal relationships.

Geographically the Maydeae are sharply divided into two groups, one in each hemisphere, and neither has ever made its way into the field of the other without the help of man. On the other hand, all the genera of each group overlap sufficiently in distribution to suggest an American progenitor and another in Australasia.

Weatherwax might quite justifiably have emphasized even more than he did the close resemblance, morphologically, of maize to its two American relatives, teosinte and Tripsacum. True, its close relationship to teosinte may be of little significance if teosinte is, as has been suggested (Mangelsdorf and Reeves, 1939), a hybrid of maize and Tripsacum. But the resemblance of maize and Tripsacum, an indigenous American species which is widely distributed in both North and South America, is greater than is commonly recognized and is certainly highly significant. In both genera one floret in each pistillate spikelet is suppressed and in both it is the lower floret which undergoes such suppression. In both genera the caryopsis is either enclosed, or surrounded at the base, by a structure which is made up of a segment of the rachis containing an alveolus, and the glumes. In Tripsacum the glumes are indurated while in maize they are often membranous or fleshy, but there is evidence from maize-teosinte crosses that this difference is in some cases a simple Mendelian one of the same general magnitude as that which distinguishes sweet corn from field corn. Maize normally bears paired pistillate spikelets and Tripsacum solitary ones, but paired spikelets have been observed in Tripsacum by Dr. Cutler and solitary spikelets in maize by Hepperly (1949), so that discontinuity between the two plants in these characters is not complete. Maize is an annual and Tripsacum a perennial possessing several characters normally associated with the perennial habit. The distinction is not of profound importance since annual and perennial species are sometimes found within the same genus. The resemblance to

Tripsacum of homozygous pod corn in bearing staminate spikelets above and pistillate spikelets below on the branches of the tassel is especially impressive.

Finally, it is possible, in spite of differences in chromosome number, to hybridize maize and Tripsacum and to demonstrate interchange between their chromosomes. There is abundant circumstantial evidence that such hybridization has occurred in the past and that it has been an important factor in the evolution of maize under domestication.

The closeness of relationship between maize and its American relatives seems to us to be far more important than the fact that maize has a larger number of relatives in Asia than in America.

In short, there is nothing in the botanical evidence of Stonor and Anderson in the three categories considered to invalidate the widely-held and well-supported opinion that maize is an American plant and there is nothing which indicates to us that maize was taken across the Pacific to Asia before 1492.

The Ethnographic Evidence

The ethnographic evidence of Stonor and Anderson, like the botanical evidence, comprises several distinct categories: (a) evidence concerned with legends and traditions; (b) names applied to maize; (c) the uses to which maize is put; (d) the role of maize in the economy of the people.

Stonor in his part of the joint paper gives unwarranted credence, we think, to statements by natives that maize is a very old crop in the region studied. For example: "The Angamis I have talked to simply state that they have grown maize from time immemorial." "The Abor tribes simply state that they have always had maize among their crops." How simplified ethnology would

be if all native informants were indeed as historically reliable as the Assamese are inferred to be. But what a confusing picture of the origin of cultivated plants one would gain by giving credence to such unsupported statements. This conviction on the part of native peoples that they have "always" had a certain plant is by no means confined to the Assamese. Dr. Carl Coons tells us that the natives of Albania are convinced that they have always had tobacco. The native peoples of the Near East are quite certain that they have always had squashes; and Irish peasants, if the question were put to them, would no doubt answer that they have always had the potato. The Indians of Central America are convinced that they have always cultivated the banana, a fact which would undoubtedly be regarded by some as evidence of early trans-Pacific diffusion. But the same Indians, or their neighbors at slightly higher altitudes, are equally sure that they have always had the broad bean *Vicia Faba*, one of Europe's principal leguminous food plants.

Legends to account for the origin of rice are regarded by Stonor as significant, since there is "no legend known to account for the origin of the other cereals; millet, maize and Job's-tears, the inference being that rice is more recent while the others are lost in the mists of antiquity." This is, to say the least, an unusual criterion of ethnological age.

Stonor found distinct names for maize in several of the tribes surveyed and regarded this as "everywhere indicative of a respectable age," and he did not consider the case weakened in instances where the tribal name indicates that it was borrowed from a neighboring people, since "the generalized name could be based on a variety got from the tribe in question and which supplanted older and more indigenous types." The fact that there is no evidence of any kind of "older and more indige-

nous types'' seems to be of no importance in answering the question of the antiquity of maize in Assam. Its antiquity seems to be a basic assumption to which the author clings despite conflicting evidence.

Particular emphasis is placed upon the multiple uses of maize among the hill tribes. These are: (1) a catch crop eaten while the grain is soft; (2) stored for winter food either as the main crop or as a reserve secondary to rice; (3) for beer making; (4) for pop corn; (5) for pig food; (6) as an article of trade outside the village.

Obviously the authors do not have a high opinion of the capabilities of pre-literate peoples: ''To have these conservative people somehow learning to use maize as a pop corn and as a green corn and as a cereal for brewing, to have them growing types of maize which are similar to each other yet rare or unknown in the New World puts the burden of proof on any one who would ascribe all this development to separate post-Columbian acquisitions.''

How else would primitive people be expected to use maize? If they use maize at all they must surely use it for food and once used for food it would be likely to be used both green and ripe, as it is in all other parts of the world where maize is grown. And if the mature maize is small and hard and capable of popping, how much ingenuity is required to put grains of maize ''into the glowing embers of the fire,'' or ''in the edge of the house fire'' picking them out with bamboo tongs as they burst? How often has the discovery been made independently that small hard kernels of maize will pop when exposed to heat? Is there any greater significance in the fact that the Assamese use maize for popping than in the fact that Asiatic people in general use seeds of species of Amaranthus for that purpose, or the fact that people throughout Latin America use hard-seeded varieties of sorghum, an African plant, for popping?

And what is so strange about using maize for brewing? Practically all of the cereals have been used for brewing in practically all parts of the world where the art of brewing has been practiced. It would be much stranger if the Assamese, "conservative" as they are said to be, did not use maize for this purpose.

Or does the feeding of maize to pigs call for an explanation? Given both maize and pigs, the problem quickly becomes one which the pig itself is likely to solve without much help from man. Domestic pigs have shared in man's principal carbohydrate foodstuffs since time immemorial and no great amount of ingenuity on the part of man is needed to establish this relationship.

The use of maize as an article of trade is too obvious to need comment.

A special use of maize in religious rituals is also regarded as a measure of antiquity. For example: "the dance of the Lakhers, the use of maize in funeral rites among the Lushais in deliberate preference to rice, its importance as a votive offering among the Monbas, the part it plays among the agricultural ritual of the Rengma Nagas, and the existence of a special tutelary deity among the Chang Nagas, all point to its being a well-established crop, the more so since primitive peoples with animistic religion are invariably shy of incorporating new crops into their agricultural ritual." Nor is negative evidence allowed to weaken this case: "I have asked members of the [Monba] tribe if they have any special rites, dances or festivals for their maize, and in all instances this was denied. I would not, however, like to state categorically that my informants were accurate. In dealings with tribal peoples knowledge of religious custom can only be got by long and close acquaintance or direct observation." And, as the author himself admits, "My notes on the religious aspect are particularly scanty." How unfortu-

nate that the author does not display the same admirable caution towards his other kinds of ethnographic data.

The position of maize relative to other crops in the economy of the hill peoples does not seem to us to have the significance which the authors attach to it. Maize, like millet and Job's-tears, is subordinated to rice among peoples living at lower altitudes, but is said to be "of more importance to the tribes living at high altitudes." While we can agree with the authors that this probably is "a state of affairs not unconnected with absence of rice varieties suitable for cold elevations," it is difficult to see how this has any bearing on their case. In view of the ethnological sequence in this region of Asia, it is not surprising to learn that rice is a relatively recent introduction among some of these tribes in spite of the fact that rice is an ancient Asiatic food crop. We cannot, however, put these circumstances together to conclude, as these authors have done, that maize is necessarily pre-Columbian in this region.

Laufer concluded some years ago that maize may have reached China as early as 1540. Goodrich (1938) dates the first Chinese reference to it at 1573. Some 400 years have now elapsed since maize came to Asia. It surely does not tax an anthropologist's credulity to believe that the Assamese and their neighbors, however conservative, have within this period learned or rediscovered or adapted to their own purposes several of the most obvious ways of using maize. Wonder would have been aroused if they had not.

Parallels between Maize in Asia and the Potato in Ireland

To those who are astonished at the extent to which maize is grown in Asia and the number of uses to which it is put and who feel that more than four centuries must

be allowed for the plant to have established itself so firmly in the economy of backward peoples, a study of the history of other cultivated plants may be revealing. Especially illuminating is a recent scholarly treatise by Salaman (1949) on the potato, and of particular interest are those chapters concerned with its history in Ireland.

Introduced into Ireland between 1586 and 1588, the potato had, within fifty years of its introduction, "become the universal and staple article of the peoples' food in the greater part of the island." Many indigenous names were invented for it: *pratie*, *tata*, *murphy*, *croker* and *buntata*. Many superstitions and social and religious customs grew up in connection with its culture. The potato was used not only for food in a variety of ways, but also medicinally and in the preparation of an alcoholic beverage. It was not only food for man, but also provided nourishment for all of his domestic animals, "the pig taking his share as readily as the wife, the cocks, hens, turkies, geese, the cur, the cat, and perhaps the cow — and all partaking of the same dish."

"So completely had the potato woven itself into the web of the life and thought of the people" that they were immune to warnings of crop failures, and "no more attention was given to such warnings than would have been the case had they been told that the rains would cease to fall from heaven." The potato, like the sun and the stars and the rain, had "always" been with them.

It may be argued that the potato became a part of the Irish culture so rapidly only because the Irish were already an advanced people. This apparently is not the case. The state of agriculture in Ireland in the sixteenth century was very primitive indeed and, in Salaman's opinion, it was this very backwardness of the Irish accompanied by general devastation and misery which lead to the breakdown of prejudice against, and the rapid accep-

tance of, a new food. Certainly the potato became much more quickly established in Ireland than in nearby England where it had been introduced even earlier. Also, it is known that both the Germans and the Scots strongly resisted the potato until famine dispelled their prejudice. Perhaps the rapidity with which a new plant is adopted by any people is less a function of their progressiveness than of their need. Seen from this viewpoint, the rapid spread of maize in Asia is not at all astonishing. In the light of the history of the potato in Ireland, post-Columbian time has been ample, and more than ample, for the introduction of maize into Asia and for its establishment as a staple crop.

The Origin of New World Cultivated Cotton and Its Bearing on Asiatic Maize

Stonor and Anderson, to support their argument for an origin or a pre-Columbian distribution of maize in Asia, cite the hypothesis of Hutchinson, Silow and Stephens (1947) which postulates that the New World cultivated cottons are tetraploid hybrids of a wild American diploid, probably *Gossypium Raimondii*, and a cultivated diploid, *G. arboreum*, introduced from Asia by man crossing the Pacific after the invention of agriculture in Asia. This hypothesis has also been cited by others (Carter, 1950; Zelinsky, 1950) as evidence of pre-Columbian trans-Pacific diffusion. It should perhaps be pointed out that many botanists, including the senior author of this paper, although they recognize the hypothesis as stimulating and provocative, are quite critical of it on genetic and botanical grounds. The reasons for this are several.

First, there is no more need of explaining the distribution of the Old and New World cottons in terms of man's peregrinations than there is of accounting for the range of numerous other genera which have a similar

geographic distribution. Indeed, if the differentiation of cotton species is to be explained in terms of man's movements, then there are other genera which are not cultivated, in which speciation ought likewise to be so explained; a procedure which would soon reduce the thesis to an absurdity.

Secondly, their classification of Gossypium, based upon the assumption of a recent origin of the New World tetraploids, is not in harmony with some of the sound taxonomic conclusions of earlier students. For example, the endemic cotton of the Galapagos Islands, formerly regarded as a good species, *G. Darwinii*, is now treated as a variety of the mainland cotton *G. barbadense*.

Finally, the endemic wild tetraploid cotton of Hawaii, *G. tomentosum*, presumably derived from the American tetraploid, presents an almost insuperable difficulty to the entire hypothesis. How could the Hawaiian cotton, in a few thousand years or less, have become so differentiated from the mainland allotetraploids that it is now generally regarded as a distinct species, since it differs in many characteristics, and since there is a high incidence of seedling mortality in the F_2 when *G. tomentosum* is crossed with the American species *G. hirsutum*. The genetic gap between the Hawaiian tetraploid and the American tetraploids is perhaps a fourth to a half as great as the gap between the American and Asiatic diploids, yet the differentiation in the one case is supposed to have required only a few thousand years, in the other, since it is assumed to have begun in the Cretaceous, some 120 million years. Differentiation of species does not, of course, proceed uniformly in time and space and the degree of differentiation is not a reliable measure of time. Yet it is difficult to believe that the rate of speciation within the same genus, and involving in part the same chromosomes, could have been roughly ten thousand

times as rapid in one period as in another. The difficulty is rendered more acute by the necessity of assuming that differentiation has been more rapid in the tetraploids than in the diploids. Few serious students of evolution will accept this premise.

In our opinion, the taxonomically distinct, wild, endemic, tetraploid cotton of Hawaii presents, for the moment at least, an insuperable obstacle to the acceptance of the conclusions of Hutchinson, Silow and Stephens. The case for the trans-Pacific, pre-Columbian diffusion of Old World cultivated cottons is no better, in our opinion, than the case for an Asiatic origin or pre-Columbian diffusion of maize. To use the one as evidence in support of the other, is to assume that two guesses have, through some strange alchemy, a greater validity than one.

Conclusion

We can find nothing in either the botanical or ethnographic evidence presented by Stonor and Anderson on Assamese maize to justify their conclusion that maize must either have originated in Asia or been taken there in pre-Columbian times. The maize itself is not unique, since it resembles the living varieties of Colombia and thus conforms to the general rule that all Old-World maize has its counterparts somewhere in America. The uses to which maize is put in Assam are exactly those to which one would expect such a cereal to be put when introduced into Asia, and there are no other special circumstances about its utilization, or the traditions connected with it, which indicate a great antiquity in Asia. The fact that maize, if introduced into Asia in post-Columbian times, must have been rapidly accepted by backward people, merely indicates that, like the potato in Ireland, it met an acute and pressing need. Cer-

tainly there is nothing in the evidence which is in conflict with the long-established and well-supported opinion that maize is an American plant—one which has perhaps been introduced into Asia twice: once in early post-Columbian times from the west by a land route, and a second time, perhaps somewhat later, when tobacco and the potato were also introduced from the east by seafaring people. There is no factual evidence in conflict with this simple and rational explanation; but there is abundant evidence to support it.

The door is still wide open for hypotheses about pre-Columbian culture diffusion between the Old World and the New, and the problem is an extremely important one which merits the most careful and critical attention on the part of scholars in several fields. The problem is not likely to be solved, however, by putting forward sweeping and sensational conclusions which are based upon inadequate and fragmentary evidence, especially when these are all too likely to be seized upon by other imaginative writers who treat them as "evidence" or, worse still, as "virtually unassailable proof" (Zelinsky, 1950).

Perhaps there has, indeed, been a pre-Columbian, trans-Pacific diffusion of culture and perhaps maize has been involved in it. To speculate upon this possibility certainly can do no harm. But fancy ought not to be confused with fact. The *fact* is, that, at the present time, there is no tangible evidence of any kind — botanical, archaeological, ethnographic, linguistic, ideographic, pictorial or historical — of the existence of maize in any part of the Old World before 1492. Until such evidence is discovered, any case for pre-Columbian, trans-Pacific diffusion must rest on evidence other than maize.

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TO GENERA AND SPECIES

ERRATA

page 25, line 31
for ramanentibus, read remanentibus

page 115, line 33
for amazónica, read amazónico

page 134, line 30
replace the comma with a period

page 150, lines 7, 10 and 15
for Matthews, read Mathews

page 195, line 31
for *Areca*, read *Acacia*

page 242, line 23
for **Kraenzlin**, read *Kraenzlin*

page 249, lines 5 and 9
for *E.*, read *A.*

page 252, line 32
for H. Perrier, read Perrier de la Bâthie

page 253, line 32
for Excell, read Exell

page 281, line 7
for Coons, read Coon

Plate XXXI
for 4, read 5; for 5, read 6; for 6, read 7; add 4 to figure at the left of 3

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